

7SR224 Recloser Controller

Overcurrent Relay

Document Release History

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Contents

Section 1: Common Functions	5
1.1 General	5
1.1.1 CE Conformity	5
1.1.2 Reference	5
1.1.3 Dimensions	5
1.1.4 Weights	6
1.2 Energising Quantities	7
1.2.1 Auxiliary Power Supply	7
1.2.2 AC Current	7
1.2.3 AC Voltage	8
1.2.4 Binary (Digital) Outputs	8
1.2.5 Binary (Digital) Inputs	9
1.3 Functional Performance	11
1.3.1 Instrumentation	11
1.3.2 USB Data Communication Interface	11
1.3.3 Fibre optic Data Communication Interface	11
1.3.4 RS485 Data Communication Interface	11
1.3.5 Additional RS485 Data Communication Interface	11
1.3.6 RS232 Data Communication Interface	11
1.3.7 Real Time Clock	11
1.4 Environmental Performance	13
1.4.1 General	13
1.4.2 Emissions	13
1.4.3 Immunity	14
1.4.4 Mechanical	15
Section 2: Protection Functions	16
2.1 27/59 Under/Over Voltage	16
2.1.1 Reference	16
2.1.2 Operate and Reset Level	16
2.1.3 Operate and Reset Time	16
2.2 37 Undercurrent	17
2.2.1 Reference	17
2.2.2 Operate and Reset Level	17
2.2.3 Operate and Reset Time	17
2.3 46NPS Negative Phase Sequence Overcurrent	18
2.3.1 Reference (46DT)	18
2.3.2 Operate and Reset Level (46DT)	18
2.3.3 Operate and Reset Time (46DT)	18
2.3.4 Reference (46IT)	19
2.3.5 Operate and Reset Level (46IT)	19
2.3.6 Operate and Reset Time (46IT)	19
2.4 47 Negative Phase Sequence Voltage	20
2.4.1 Reference (47)	20
2.4.2 Operate and Reset Level (47)	20
2.4.3 Operate and Reset Time (47)	20
2.5 49 Thermal Overload	21
2.5.1 Reference	21
2.5.2 Operate and Reset Level	21
2.5.3 Operate and Reset Time	21
2.6 50 Instantaneous Overcurrent	23
2.6.1 Reference	23
2.6.2 Operate and Reset Level	23
2.6.3 Operate and Reset Time	23
2.7 50G Instantaneous Measured Earth Fault	24
2.7.1 Reference	24
2.7.2 Operate and Reset Level	24
2.7.3 Operate and Reset Time	24
2.8 50SEF Instantaneous Sensitive Earth Fault	25
2.8.1 Reference	25
2.8.2 Operate and Reset Level	25

2.8.3	Operate and Reset Time.....	25
2.9	51 Time Delayed Overcurrent.....	26
2.9.1	Reference.....	26
2.9.2	Operate and Reset Level.....	26
2.9.3	Operate and Reset Time.....	27
2.10	51G Time Delayed Measured Earth Fault.....	28
2.10.1	Reference.....	28
2.10.2	Operate and Reset Level.....	28
2.10.3	Operate and Reset Time.....	29
2.11	51SEF Time Delayed Sensitive Earth Fault.....	33
2.11.1	Reference.....	33
2.11.2	Operate and Reset Level.....	33
2.11.3	Operate and Reset Time.....	34
2.12	51V Voltage Controlled Overcurrent.....	35
2.12.1	Reference.....	35
2.12.2	Operate and Reset Level.....	35
2.13	59N Neutral Voltage Displacement.....	36
2.13.1	Reference (59NDT).....	36
2.13.2	Operate and Reset Level (59NDT).....	36
2.13.3	Operate and Reset Time (59NDT).....	36
2.13.4	Reference (59NIT).....	36
2.13.5	Operate and Reset Level (59NIT).....	36
2.13.6	Operate and Reset Time (59NIT).....	37
2.14	64H Restricted Earth Fault Protection.....	38
2.14.1	Reference.....	38
2.14.2	Operate and Reset Level.....	38
2.14.3	Operate and Reset Time.....	38
2.15	67/67G/67SEF Directional Overcurrent & Earth Fault.....	39
2.15.1	Reference.....	39
2.15.2	Operate Angle.....	39
2.15.3	Operate Threshold.....	39
2.15.4	Minimum Polarising Voltage Level.....	39
2.15.5	Operate and Reset Time.....	39
2.16	81Under/Over Frequency.....	40
2.16.1	Reference.....	40
2.16.2	Operate and Reset Level.....	40
2.16.3	Operate and Reset Time.....	40
Section 3: Supervision Functions.....		41
3.1	46BC Broken Conductor.....	41
3.1.1	Reference.....	41
3.1.2	Operate and Reset Level.....	41
3.1.3	Operate and Reset Time.....	41
3.2	50BF Circuit Breaker Fail.....	42
3.2.1	Reference.....	42
3.2.2	Operate and Reset Level.....	42
3.2.3	Operate and Reset Time.....	42
3.3	60CTS Current Transformer Supervision.....	43
3.3.1	Reference.....	43
3.3.2	Current & Voltage Threshold.....	43
3.3.3	Operate and Reset Time.....	43
3.4	60VTS Voltage Transformer Supervision.....	44
3.4.1	Reference (60VTS).....	44
3.4.2	Operate and Reset Level.....	44
3.4.3	Operate and Reset Time.....	44
3.5	60VTF-Bus Voltage Transformer Supervision.....	45
3.5.1	Reference (60VTF).....	45
3.5.2	Operate and Reset Time.....	45
3.6	74TCS Trip Circuit Supervision.....	45
3.6.1	Operate and Reset Time.....	45
3.7	81HBL2 Inrush Detector.....	46
3.7.1	Reference.....	46
3.7.2	Operate and Reset Level.....	46
3.7.3	Operate and Reset Time.....	46

Section 4: Control Functions	47
4.1 Check Synchronising	47
4.1.1 Reference	47
4.1.2 Live/Dead Line/Bus Detector Elements	47
4.1.3 Line and Bus Undervoltage Elements	47
4.1.4 Voltage Difference	48
4.1.5 General Autoreclose Timers	48
4.1.6 CS/SS/COZ Line and Bus Phase Angle Difference	48
4.1.7 CS/SS/COZ Slip Frequency	48
4.1.8 CS/SS Timer	48
4.1.9 Split Angle Detector	48
4.1.10 Split Slip Frequency Detector	48
4.2 Loss of Voltage (LOV) Loop Automation Function	49
4.2.1 Reference (LOV-A/X Dead/Live)	49
4.2.2 Operate and Reset Level	49
4.2.3 Reference LOV Automation Timers	49
4.2.4 Operate Time LOV Automation Timers	49

List of Figures

Figure 1-1 Binary Input Configurations Providing Compliance with EATS 48-4 Classes ESI 1 and ESI 2	10
Figure 2-1 Thermal Overload Protection Curves	22
Figure 2-2 IEC IDMTL Curves (Time Multiplier=1)	30
Figure 2-3 ANSI IDMTL Operate Curves (Time Multiplier=1)	31
Figure 2-4 ANSI Reset Curves (Time Multiplier=1)	32

Section 1: Common Functions

1.1 General

1.1.1 CE Conformity

CE This product is CE compliant to relevant EU directives.

1.1.2 Reference

This product complies with IEC 60255-3, IEC 60255-6 and IEC 60255-12.

1.1.2.1 Accuracy Reference Conditions

This product has been tested under the following conditions, unless specifically stated otherwise.

Parameter	Value
Auxiliary supply	nominal
Frequency	nominal
Ambient temperature	20 °C

1.1.3 Dimensions

Parameter	Value	
Width	E10 case	260 mm
	E12 case	312 mm
Height	177 mm	
Depth behind panel (including clearance for wiring and fibre)	287 mm	
Projection (from front of panel)	31 mm	

See appropriate case outline and panel drilling drawing, as specified in Diagrams and Parameters document, for complete dimensional specifications.

1.1.4 Weights

Parameter		Value
Net weight	7SR2241, E10 case	5.98kg
	7SR2242, E10 case	5.98kg
	7SR2243, E10 case	5.98kg
	7SR2244, E10 case	5.98kg
	7SR2245, E10 case	5.98kg
	7SR2246, E12 case	7.43kg
	7SR2247, E12 case	7.80kg
	7SR2248, E12 case	7.80kg

1.2 Energising Quantities

1.2.1 Auxiliary Power Supply

Nominal		Operating Range
V_{AUX}	30, 48, 110, 220 VDC	24 to 290 VDC

1.2.1.1 Burden

Attribute		Value
30V DC	Quiescent (typical)	6.0 W
	Quiescent (back light)	7.0 W
48V DC	Quiescent (typical)	5.5W
	Quiescent (back light)	6.5W
110V DC	Quiescent (typical)	6.5W
	Quiescent (back light)	7.5W
220V DC	Quiescent (typical)	7.5W
	Quiescent (back light)	8.5W

1.2.2 AC Current

Nominal		Measuring Range
I_n	1, 5 A Phase and earth	$80 \times I_n$
f_n	50, 60Hz	47 to 62Hz

Note. 1 A and 5 A nominal inputs are user selectable on each model.

1.2.2.1 Burden

Attribute	Value - Phase and Earth	
	1A	5A
AC Burden	$\leq 0.1 \text{ VA}$	$\leq 0.3 \text{ VA}$

1.2.2.2 Thermal Withstand

Overload Period	Overload Current	
	Phase and Earth	
	1A	5A
Continuous	$3.0 \times I_n$	
10 minutes	$3.5 \times I_n$	
5 minutes	$4.0 \times I_n$	
3 minutes	$5.0 \times I_n$	
2 minutes	$6.0 \times I_n$	
3 seconds	57.7A	202A
2 seconds	70.7A	247A
1 second	100A	350A
1 cycle	700A	2500A

1.2.3 AC Voltage

Nominal		Operating Range
V_n	63.5V, 110 V	270 V
f_n	50, 60Hz	47 to 62Hz

1.2.3.1 Burden

Attribute	Value
AC Burden	≤ 0.1 VA at 110 V

1.2.4 Binary (Digital) Outputs

Contact rating to IEC 60255-0-2

Attribute		Value
Carry continuously		5A AC or DC
Make and carry ($L/R \leq 40$ ms and $V \leq 300$ V)	for 0.5 s	20A AC or DC
	for 0.2 s	30A AC or DC
Break (≤ 5 A and ≤ 300 V)	AC resistive	1250 VA
	AC inductive	250 VA at p.f. ≤ 0.4
	DC resistive	75 W
	DC inductive	30 W at $L/R \leq 40$ ms 50 W at $L/R \leq 10$ ms
Contact Operate / Release Time		7ms / 3ms
Minimum number of operations		1000 at maximum load
Minimum recommended load		0.5 W at minimum of 10mA or 5V

1.2.5 Binary (Digital) Inputs

Nominal		Operating Range
V_{BI}	19 VDC	17 to 290 VDC
	88 VDC	74 to 290 VDC

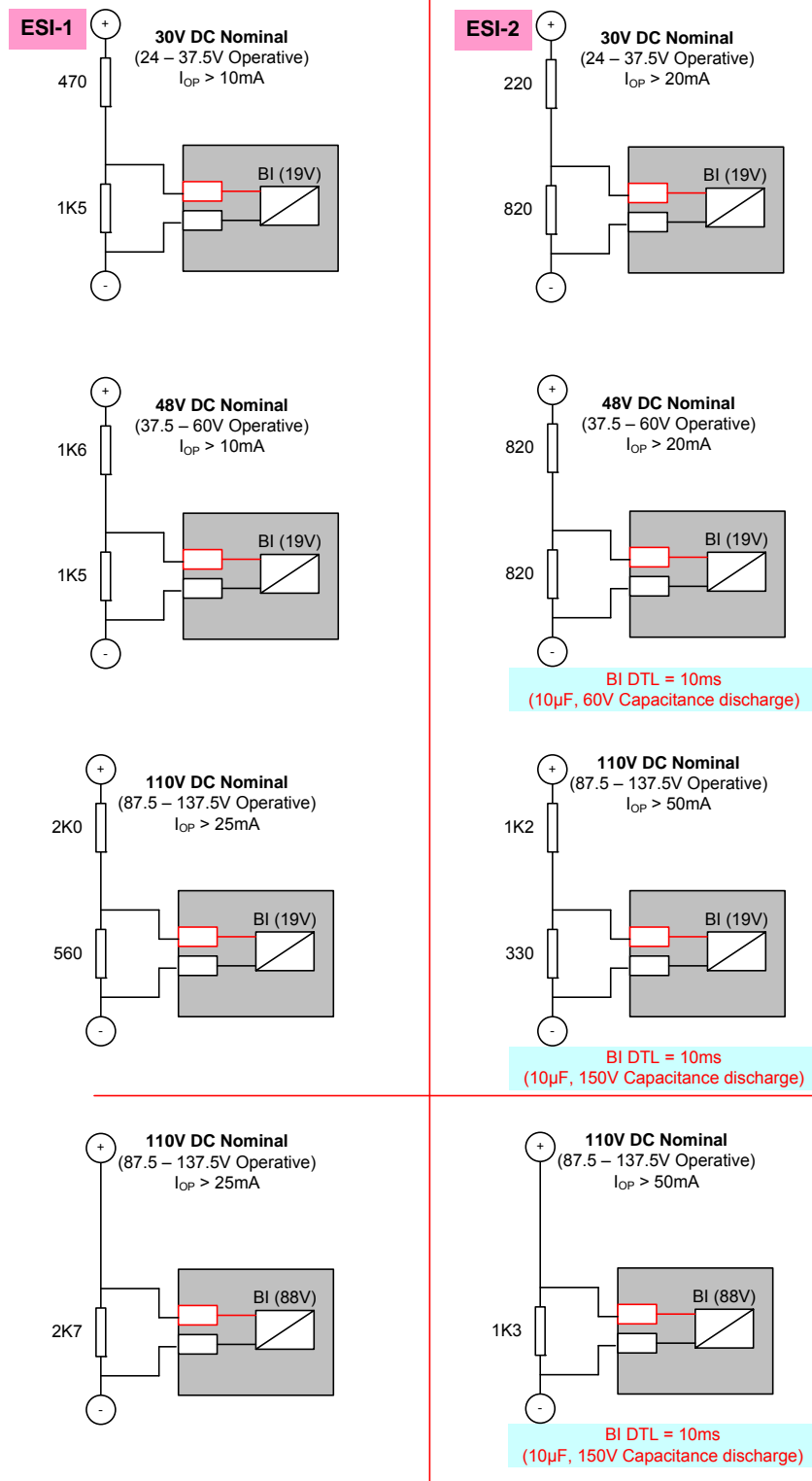
1.2.5.1 Performance

Attribute		Value
Maximum DC current for operation	$V_{BI} = 19\text{ V}$	1.5mA
	$V_{BI} = 88\text{ V}$	1.5mA
Reset/Operate voltage ratio		$\geq 90\%$
Typical response time		< 7ms
Typical response time when programmed to energise an output relay contact		< 20ms

The binary inputs have a low minimum operate current and may be set for high speed operation. To achieve immunity from AC interference, a BI pick-up delay of typically one-cycle can be applied. The default pick-up time delay of 20ms will provide this immunity.

The standard EATS 48-4 specifies additional performance requirements to provide greater security against external disturbances. This standard can be applied to applications where a binary input is used to influence a control function (e.g. provide a tripping function) and the wiring is considered to be susceptible to capacitive currents, but double pole switching is not applied. See Chapter 7 Applications Guide.

To comply with EATS 48-4, classes ESI 1 and ESI 2, external components / BI pick-up delays are required as shown in fig. 1-1.



Resistor power ratings: 30V DC Nominal >3W
 48V DC Nominal >3W
 110V DC Nominal >10W (ESI- 1)
 110V DC Nominal >20W (ESI-2)

Resistors must be wired with crimped connections as they may run hot

Figure 1-1 Binary Input Configurations Providing Compliance with EATS 48-4 Classes ESI 1 and ESI 2

1.3 Functional Performance

1.3.1 Instrumentation

	Instrument Value	Reference	Typical accuracy
I	Current	$I \geq 0.1 \times I_n$	$\pm 1 \% I_n$
V	Voltage	$V \geq 0.8 \times V_n$	$\pm 1 \% V_n$

1.3.2 USB Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	USB-Type B

1.3.3 Fibre optic Data Communication Interface

Attribute	Value
Physical layer	Fibre-optic
Connectors	ST TM (BFOC/2.5)
Recommended fibre	62.5/125 μ m glass fibre with ST connector
Launch power (into recommended fibre)	-16 dBm
Receiver sensitivity	-24 dBm

1.3.4 RS485 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	4mm Ring Crimp

1.3.5 Additional RS485 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	Screw retainer terminal to suit Flat Blade Crimps up to 2.5mm

1.3.6 RS232 Data Communication Interface

Attribute	Value
Physical layer	Electrical
Connectors	9 way Male 'D' connector

1.3.7 Real Time Clock

1.3.7.1 Internal Clock

The specification below applies only while no external synchronisation signal (e.g. IRIG-B, IEC 60870-5-103) is being received.

Attribute	Value
Accuracy (-10 to +55°C)	± 3.5 ppm

1.3.7.2 IRIG-B

Attribute	Value
Connector	BNC
Signal Type	IRIG-B 120, 122 or 123
Applied signal level	minimum 3 V, maximum 6 V, peak-to-peak
Signal : carrier ratio	≥ 3

1.4 Environmental Performance

1.4.1 General

1.4.1.1 Temperature

IEC 60068-2-1/2

Type	Level
Operating range	-10 °C to +55 °C
Storage range	-25 °C to +70 °C

1.4.1.2 Humidity

IEC 60068-2-3

Type	Level
Operational test	56 days at 40 °C and 95 % relative humidity

1.4.1.3 Transient Overvoltage

IEC 60255-5

Type	Level
Between all M4 terminals and earth, or between any two independent circuits	5.0 kV, 1.2/50 μ s 0.5j

1.4.1.4 Insulation

IEC 60255-5

Type	Level
Between any M4 terminal and earth	2.5 kV AC RMS for 1 min
Between independent circuits	
Across normally open contacts	1.0 kV AC RMS for 1 min

1.4.1.5 IP Ratings

Type	Level
Installed with cover on	IP 50 from front
Installed with cover removed	IP 30 from front

1.4.2 Emissions

IEC 60255-25

1.4.2.1 Radiated Radio Frequency

Type	Limits at 10 m, Quasi-peak
30 to 230 MHz	40 dB(μ V/m)
230 to 10000 MHz	47 dB(μ V/m)

1.4.2.2 Conducted Radio Frequency

Type	Limits	
	Quasi-peak	Average
0.15 to 0.5 MHz	79 dB(μ V)	66 dB(μ V)
0.5 to 30 MHz	73 dB(μ V)	60 dB(μ V)

1.4.3 Immunity

1.4.3.1 Auxiliary DC Supply Variation

Quantity	Value
Allowable superimposed ac component	≤ 12% of DC voltage
Allowable breaks/dips in supply (collapse to zero from nominal voltage)	≤ 20ms

1.4.3.2 High Frequency Disturbance

IEC 60255-22-1 Class III

Type	Level	Variation
Common (longitudinal) mode	2.5 kV	≤ 5 %
Series (transverse) mode	1.0 kV	

1.4.3.3 Electrostatic Discharge

IEC 60255-22-2 Class IV

Type	Level	Variation
Contact discharge	8.0 kV	≤ 5 %

1.4.3.4 Radiated Immunity

IEC 60255-22-3 Class III

Type	Level	Variation
80 MHz to 1000 MHz	10 V/m	≤ 5 %

1.4.3.5 Fast Transients

IEC 60255-22-4 Class IV

Type	Level	Variation
5/50 ns 2.5 kHz repetitive	4kV	≤ 5 %

1.4.3.6 Surge Immunity

IEC 60255-22-5

Type	Level	Variation
Between all terminals and earth	4.0 kV	≤ 10 %
Between Line to Line	2.0 kV	

1.4.3.7 Conducted Radio Frequency Interference

IEC 60255-22-6

Type	Level	Variation
0.15 to 80 MHz	10 V	≤ 5 %

1.4.4 Mechanical

1.4.4.1 Vibration (Sinusoidal)

IEC 60255-21-1 Class I

Type	Level	Variation
Vibration response	0.5 gn	≤ 5 %
Vibration endurance	1.0 gn	

1.4.4.2 Shock and Bump

IEC 60255-21-2 Class I

Type	Level	Variation
Shock response	5 gn, 11 ms	≤ 5 %
Shock withstand	15 gn, 11 ms	
Bump test	10 gn, 16 ms	

1.4.4.3 Seismic

IEC 60255-21-3 Class I

Type	Level	Variation
Seismic response	1 gn	≤ 5 %

1.4.4.4 Mechanical Classification

Type	Level
Durability	> 10 ⁶ operations

Section 2: Protection Functions

2.1 27/59 Under/Over Voltage

2.1.2 Reference

	Parameter	Value
V_s	Setting	5, 5.5...200V
$hyst$	Hysteresis setting	0, 0.1... 80.0%
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.1.3 Operate and Reset Level

	Attribute	Value
V_{op}	Operate level	100 % V_s , ± 1 % or $\pm 0.25V$
	Reset level	Overvoltage = $(100 \% - hyst) \times V_{op}$, ± 1 % or 0.25V
		Undervoltage = $(100 \% + hyst) \times V_{op}$, ± 1 % or 0.25V
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C ≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz ≤ 5 %

2.1.4 Operate and Reset Time

	Attribute	Value	
t_{basicE}	Element basic operate time. Standard & LOV models	Overvoltage	0 to 1.1 x V_s : 73 ms \pm 10ms
		Overvoltage	0 to 2.0 x V_s : 63 ms \pm 10ms
	Element basic operate time. Single-Triple model only	Undervoltage	1.1 to 0.5 x V_s : 58 ms \pm 10ms
		Overvoltage	0 to 1.1 x V_s : 81 ms \pm 10ms
		Overvoltage	0 to 2.0 x V_s : 71 ms \pm 10ms
		Undervoltage	1.1 to 0.5 x V_s : 64 ms \pm 10ms
t_{op}	Operate time following delay	$t_{basic} + t_d$, ± 1 % or $\pm 10ms$	
	Repeatability	± 1 % or $\pm 10ms$	
	Disengaging time	< 80 ms	

2.2 37 Undercurrent

2.2.2 Reference

	Parameter	Value
I_s	Setting	0.05, 0.10...5.0 xIn
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.2.3 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\leq 105\%$ I_{op}
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.2.4 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	1.1 to 0.5 x/s: 35 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 60\text{ ms}$

2.3 46NPS Negative Phase Sequence Overcurrent

2.3.1 Reference (46DT)

	Parameter	Value
I_s	Setting	0.05, 0.06... 4.0xIn
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.3.2 Operate and Reset Level (46DT)

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.3.3 Operate and Reset Time (46DT)

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 xIs: 40 ms, $\pm 10\text{ms}$
		0 to 5 xIs: 30 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	<40 ms
	Disengaging time	< 60 ms

2.3.4 Reference (46IT)

	Parameter	Value
<i>char</i>	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL
<i>Tm</i>	Time Multiplier setting	0.025, 0.050 ... 1.6
<i>I_s</i>	Setting	0.05, 0.06... 2.5xIn
<i>I</i>	Applied Current (for operate time) IDMTL	2 to 20 x Is
<i>t_d</i>	Delay setting	0, 0.01... 20 s
<i>t_{res}</i>	Reset setting	ANSI DECAIVING, 0, 1... 60 s

2.3.5 Operate and Reset Level (46IT)

	Attribute	Value
<i>I_{op}</i>	Operate level	105 % <i>I_s</i> , ± 4 % or ± 1% <i>I_n</i>
	Reset level	≥ 95 % <i>I_{op}</i>
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C
		<i>f_{nom}</i> - 3 Hz to <i>f_{nom}</i> + 2 Hz

2.3.6 Operate and Reset Time (46IT)

	Attribute	Value
	Starter operate time (≥ 2x/ <i>I_s</i>)	35 ms, ± 10ms
<i>t_{op}</i>	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5 \% \text{ absolute or } \pm 50 \text{ ms,}$ for char = IEC-NI : K = 0.14, α = 0.02 IEC-VI : K = 13.5, α = 1.0 IEC-EI : K = 80.0, α = 2.0 IEC-LTI : K = 120.0, α = 1.0
		$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5 \% \text{ absolute or } \pm 50 \text{ ms,}$ for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
	<i>char</i> = DTL	<i>t_d</i> , ± 1 % or ± 20ms
	Reset time	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5 \% \text{ absolute or } \pm 50 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		<i>t_{res}</i>
	Repeatability	± 1 % or ± 20ms
	Overshoot time	< 40 ms
	Disengaging time	< 60 ms

2.4 47 Negative Phase Sequence Voltage

2.4.1 Reference (47)

	Parameter	Value
V_s	Setting	1, 1.5... 90V
$Hyst.$	Hysteresis	0, 0.1... 80%
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.4.2 Operate and Reset Level (47)

	Attribute	Value
V_{op}	Operate level	$(100\% - hyst) \times V_{op}$, $\pm 1\%$ or $\pm 0.25\text{ V}$
	Reset level	$\geq 95\% V_{op}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$

2.4.3 Operate and Reset Time (47)

	Attribute	Value
t_{basic}	Element basic operate time	0V to 2 xVs, 80 ms, $\pm 20\text{ms}$
		0V to 10 xVs, 55 ms, $\pm 20\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 2\%$ or $\pm 20\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 20\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 60\text{ ms}$

2.5 49 Thermal Overload

2.5.1 Reference

	Parameter	Value
I_s	Overload setting	0.10, 0.11... 3 I_n
τ	Time constant setting	1, 1.5... 1000 min

2.5.2 Operate and Reset Level

	Attribute	Value
I_{ol}	Overload level	100 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
	Reset level	$\geq 95\% I_{ol}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.5.3 Operate and Reset Time

	Attribute	Value
t_{op}	Overload trip operate time	$t = \tau \times \ln \left\{ \frac{I^2 - I_p^2}{I^2 - (k \times I_B)^2} \right\}$, $\pm 5\%$ absolute or $\pm 100\text{ms}$, where I_p = prior current
	Repeatability	$\pm 100\text{ms}$

Figure 2-1 shows the thermal curves for various time constants.

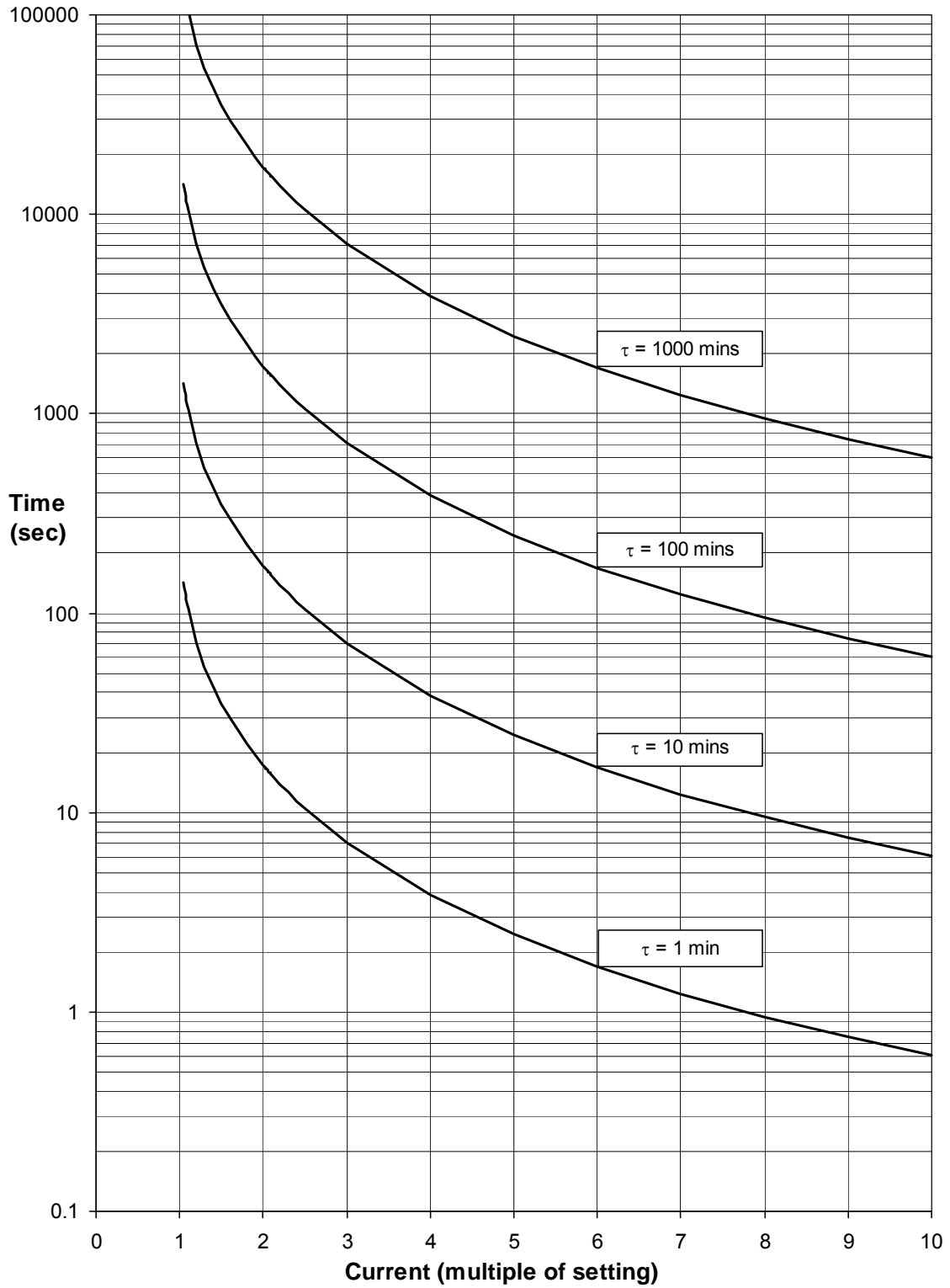


Figure 2-1 Thermal Overload Protection Curves

2.6 50 Instantaneous Overcurrent

2.6.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06 ...2, 2.05... 25, 25.5... 50 xIn
I	Applied Current (for operate time)	5 xIs
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.6.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach (X/R ≤ 100)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.6.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 xIs: 35 ms, $\pm 10\text{ms}$
		0 to 5 xIs: 25 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.7 50G Instantaneous Measured Earth Fault

2.7.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.006 ... 0.1, 0.105 .. 2.5, 2.55 ... 25 xIn
I	Applied Current (for operate time)	5 x Is
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.7.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ I_{op}
	Repeatability	$\pm 1\%$
	Transient overreach (X/R ≤ 100)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.7.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 xIs: 35 ms, $\pm 10\text{ms}$
		0 to 5 xIs: 25 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.8 50SEF Instantaneous Sensitive Earth Fault

2.8.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.006 ... 0.1, 0.105 .. 5 x/n
t_d	Delay setting	0.00 , 0.01... 20.0, 20.1 .. 100.0, 101....1000, 1010 ... 10000 , 10100 ... 14400
I	Applied current (for operate time)	5 x/ I_s

2.8.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\%$ I_n
	Reset level	$\geq 95\%$ $I_{op} \pm 5\%$ or $\pm 1\%$ I_n
	Repeatability	$\pm 1\%$
	Transient overreach (X/R ≤ 100)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz to } f_{nom} + 2\text{ Hz}$ harmonics to f_{cutoff}
		$\leq 5\%$
		$\leq 5\%$

2.8.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 x/ I_s : 35 ms, $\pm 10\text{ms}$
		0 to 5 x/ I_s : 25 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms
	Variation	$f_{nom} - 3\text{ Hz to } f_{nom} + 2\text{ Hz}$
		$\leq 5\%$

2.9 51 Time Delayed Overcurrent

2.9.1 Reference

	Parameter	Value
I_s	Setting	0.05, 0.06... 2.5 xI_n
$char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL Manufacturer specific curves See 'Performance Specification Appendix 1'
T_m	Time Multiplier setting	0.025, 0.05... 1.6
I	Applied current (for operate time)	IDMTL 2 to 20 xI_s
		DTL 5 xI_s
t_d	Delay setting	0, 0.01... 20 s
t_{res}	Reset setting	ANSI DECAYING, 0, 1... 60 s

2.9.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	105 % I_s , ± 4 % or ± 1 % I_n
	Reset level	≥ 95 % I_{op}
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz
		≤ 5 %
		≤ 5 %

2.9.3 Operate and Reset Time

	Attribute	Value
	Starter operate time ($\geq 2xI_s$)	20 ms, ± 20 ms
t_{op}	Operate time	$char = \text{IEC-NI, IEC-VI, IEC-EI, IEC-LTI}$ $t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$char = \text{ANSI-MI, ANSI-VI, ANSI-EI}$ $t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
	$char = \text{DTL}$	$t_d, \pm 1\% \text{ or } \pm 20\text{ms}$
	Reset time	$ANSI \text{ DECAYING}$ $t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^P - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		t_{res}
	Repeatability	$\pm 1\% \text{ or } \pm 20\text{ms}$
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

Figure 2-2 shows the operate times for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2-3 shows the ANSI IDMTL Operate Curves (Time Multiplier=1) and Figure 2-4 shows the ANSI Reset Curves (Time Multiplier = 1). These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

2.10 51G Time Delayed Measured Earth Fault

2.10.1 Reference

	Parameter	Value	
I_s	Setting	0.005, 0.006 ... 0.100, 0.105... 1.0 $x I_n$	
$Char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL Manufacturer specific curves See 'Performance Specification Appendix 1'	
T_m	Time Multiplier setting	0.025, 0.05... 1.6	
t_d	Delay setting (DTL)	0, 0.01... 20 s	
t_{res}	Reset setting	ANSI DECAYING, 0, 1... 60 s	
I	Applied current (for operate time)	IDMTL	2 to 20 $x I_s$
		DTL	5 $x I_s$

2.10.2 Operate and Reset Level

	Attribute	Value	
I_{op}	Operate level	105 % I_s , ± 4 % or ± 1 % I_n	
	Reset level	≥ 95 % I_{op}	
	Repeatability	± 1 %	
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz	≤ 5 %

2.10.3 Operate and Reset Time

	Attribute	Value
	Starter operate time ($\geq 2xI_s$)	20 ms, ± 20 ms
t_{op}	Operate time	$char = \text{IEC-NI, IEC-VI, IEC-EI, IEC-LTI}$ $t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
		$char = \text{ANSI-MI, ANSI-VI, ANSI-EI}$ $t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
	$char = \text{DTL}$	$t_d, \pm 1\% \text{ or } \pm 20\text{ms}$
	Reset time	$ANSI \text{ DECAYING}$ $t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^2 - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
		t_{res}
	Repeatability	$\pm 1\% \text{ or } \pm 20\text{ms}$
	Overshoot time	< 40 ms
	Disengaging time	< 50 ms

Figure 2-2 shows the operate times for the four IEC IDMTL curves with a time multiplier of 1.

Figure 2-3 shows the ANSI IDMTL Operate Curves (Time Multiplier=1) and Figure 2-4 shows the ANSI Reset Curves (Time Multiplier = 1). These operate times apply to non-directional characteristics. Where directional control is applied then the directional element operate time should be added to give total maximum operating time.

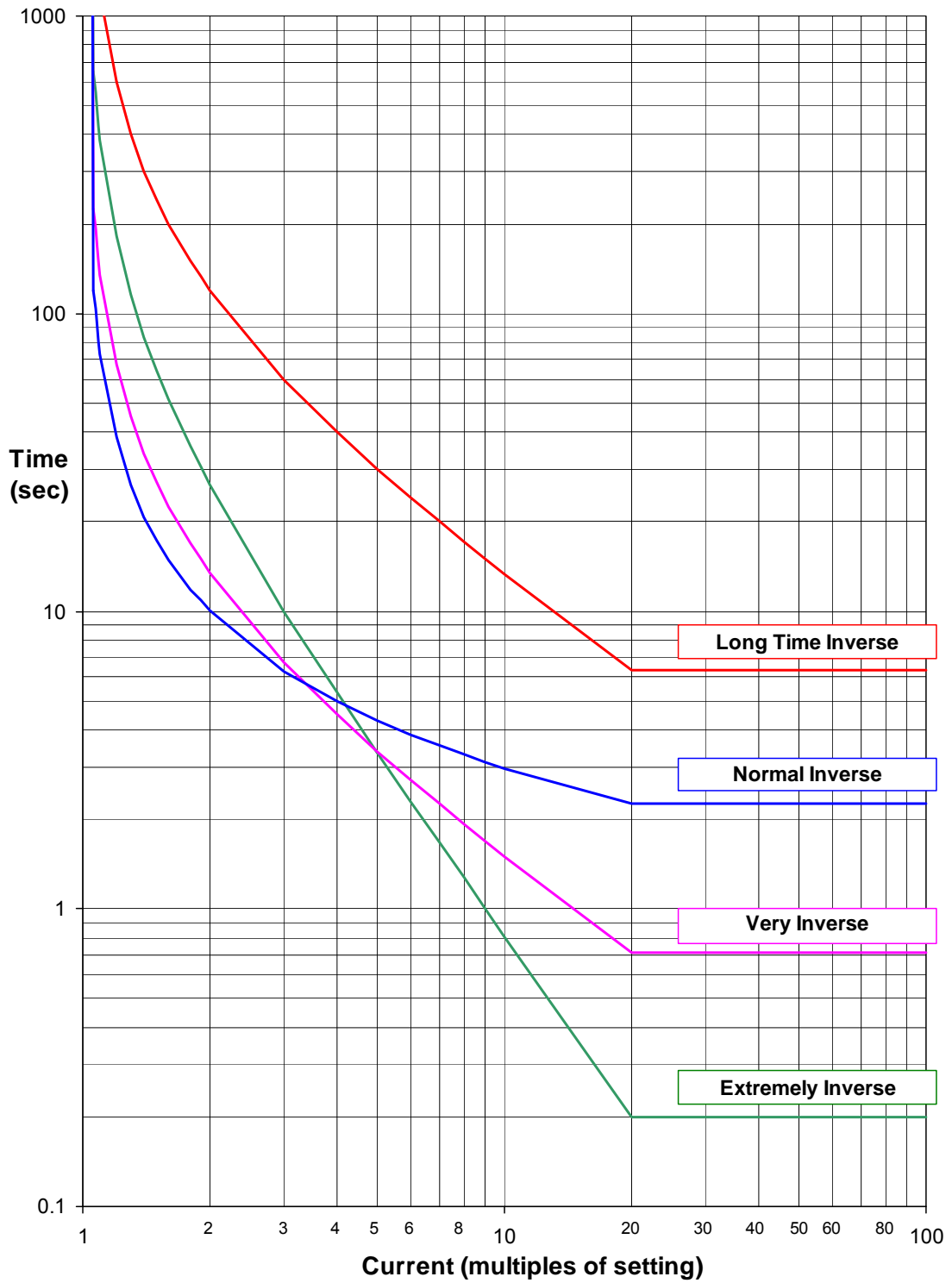


Figure 2-2 IEC IDMTL Curves (Time Multiplier=1)

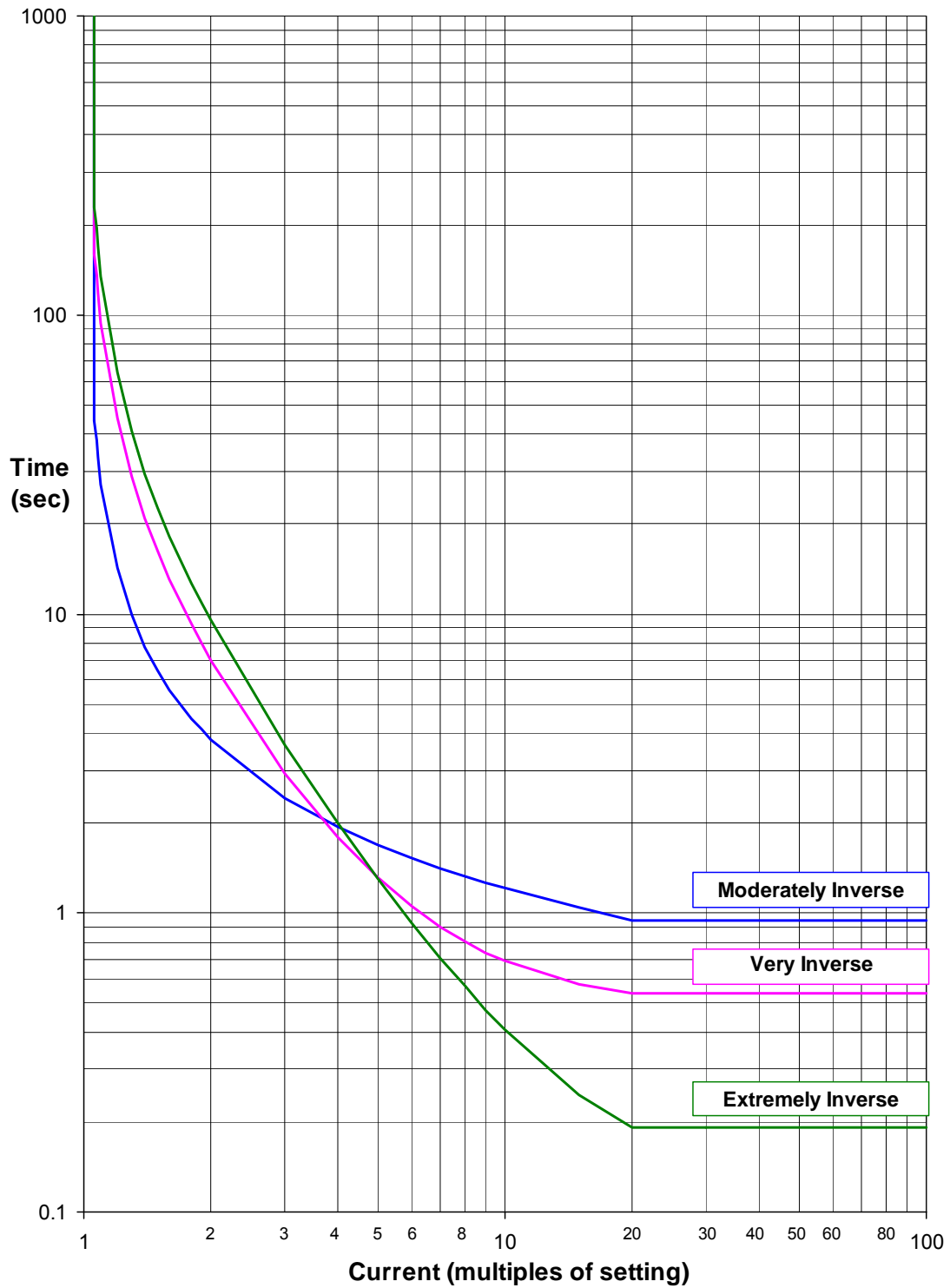


Figure 2-3 ANSI IDMTL Operate Curves (Time Multiplier=1)

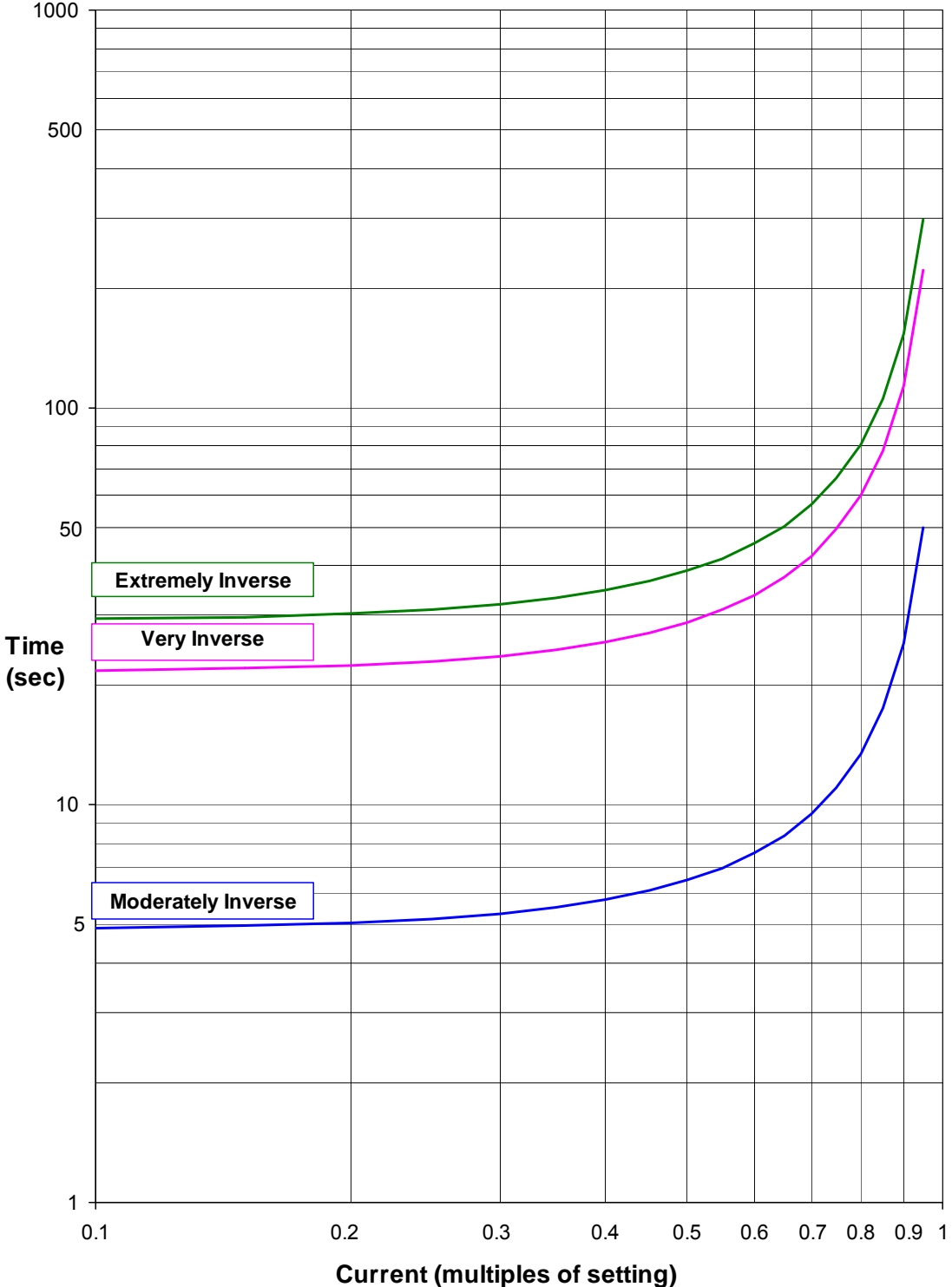


Figure 2-4 ANSI Reset Curves (Time Multiplier=1)

2.11 51SEF Time Delayed Sensitive Earth Fault

2.11.1 Reference

	Parameter	Value	
I_s	Setting	0.005, 0.006 ...0.100, 0.105... 1.0 $\times I_n$	
$char$	Characteristic setting	IEC-NI, -VI, -EI, -LTI; ANSI-MI, -VI, -EI; DTL Manufacturer specific curves See 'Performance Specification Appendix 1'	
T_m	Time multiplier	1.0	
t_d	Delay setting	0.00...20.00 s	
t_{res}	Reset setting	DECAYING, 0, 1...60 s	
I	Applied current (for operate time)	IDMTL	2 to 20 $\times I_s$
		DTL	5 $\times I_s$

2.11.2 Operate and Reset Level

	Attribute	Value	
I_{op}	Operate level	105 % I_s , ± 4 % or ± 1 % I_n	
	Reset level	≥ 95 % $I_{op} \pm 4$ % or ± 1 % I_n	
	Repeatability	± 1 %	
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz	≤ 5 %
		harmonics to f_{cutoff}	

2.11.3 Operate and Reset Time

Attribute		Value
Starter operate time		20 ms, $\pm 20ms$
t_{op}	Operate time	$t_{op} = \frac{K}{\left[\frac{I}{I_s}\right]^\alpha - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = IEC-NI : K = 0.14, $\alpha = 0.02$ IEC-VI : K = 13.5, $\alpha = 1.0$ IEC-EI : K = 80.0, $\alpha = 2.0$ IEC-LTI : K = 120.0, $\alpha = 1.0$
	Operate time	$t_{op} = \left[\frac{A}{\left[\frac{I}{I_s}\right]^P - 1} + B \right] \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : A = 0.0515, B = 0.114, P = 0.02 ANSI-VI : A = 19.61, B = 0.491, P = 2.0 ANSI-EI : A = 28.2, B = 0.1217, P = 2.0
	char = DTL	$t_d, \pm 1\% \text{ or } \pm t_{cycle}$
Reset time	char = ANSI and $t_{res} = \text{DECAYING}$	$t_{res} = \frac{R}{\left[\frac{I}{I_s}\right]^P - 1} \times Tm, \pm 5\% \text{ absolute or } \pm 30 \text{ ms,}$ for char = ANSI-MI : R = 4.85 ANSI-VI : R = 21.6 ANSI-EI : R = 29.1
	$t_{res} \neq \text{DECAYING}$	$t_{res}, \pm 1\% \text{ or } \pm 20ms$
Repeatability		$\pm 1\% \text{ or } \pm 20ms$
Overshoot time		< 40 ms
Disengaging time		< 50 ms
Variation	$f_{nom} - 3 \text{ Hz}$ to $f_{nom} + 2 \text{ Hz}$ harmonics to f_{cutoff}	$\leq 5\%$

2.12 51V Voltage Controlled Overcurrent

2.12.1 Reference

	Parameter	Value
V_s	Setting	60V
m	multiplier	0.5
I_s	Setting	1xIn

2.12.2 Operate and Reset Level

	Attribute	Value
V_{op}	Operate level	100 % V_s , ± 1 % or $\pm 0.25V$
	Reset level	≤ 105 % V_{op}
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C ≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz ≤ 5 %
		harmonics to f_{cutoff}

Operate and Reset Time

As per Phase Fault Shaped Characteristic Element (ANSI 51).

Where Pickup Level = I_s for Voltage > V_s

Pickup Level = ($I_s \times m$) for Voltage < V_s

2.13 59N Neutral Voltage Displacement

2.13.1 Reference (59NDT)

	Parameter	Value
V_s	Setting	1, 1.5... 100V
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

2.13.2 Operate and Reset Level (59NDT)

	Attribute	Value
V_{op}	Operate level	100 % V_s , $\pm 2\%$ or $\pm 0.5\text{ V}$
	Reset level	$\geq 95\%$ V_{op} or $V_{op} \pm 0.25\text{V}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.13.3 Operate and Reset Time (59NDT)

	Attribute	Value
t_{basic}	Element basic operate time	0V to 1.5 x V_s , 76 ms, $\pm 20\text{ms}$
		0V to 10 x V_s , 63 ms, $\pm 20\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 20\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 20\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.13.4 Reference (59NIT)

	Parameter	Value
M	Multiplier setting	0.1, 0.2... 10, 10.5... 140
V_s	Setting	1, 1.5... 100V
t_d	Delay setting	0, 0.01... 20 s
t_{res}	Reset setting	0, 1...60 s

2.13.5 Operate and Reset Level (59NIT)

	Attribute	Value
V_{op}	Operate level	105 % V_s , $\pm 2\%$ or $\pm 0.5\text{ V}$
	Reset level	$\geq 95\%$ V_{op} or $V_{op} \pm 0.25\text{V}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.13.6 Operate and Reset Time (59NIT)

	Attribute		Value
t_{basic}	Starter operate time ($\geq 2xVs$)		65 ms, ± 20 ms
t_{op}	Operate time	char = IDMTL	$t_{op} = \frac{M}{\left[\frac{3V_0}{Vs}\right] - 1}$, $\pm 5\%$ or ± 65 ms
		char = DTL	t_d , $\pm 1\%$ or ± 40 ms
	Reset Time	char = IDMTL	t_{res} , $\pm 5\%$ or ± 65 ms
		char = DTL	t_{res} , $\pm 1\%$ or ± 40 ms
	Repeatability		$\pm 1\%$ or ± 20 ms
	Overshoot time		< 40 ms
	Disengaging time		< 50 ms

2.14 64H Restricted Earth Fault Protection

2.14.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.006 ..0.100, 0.105... 0.95 xI_n
t_d	Delay setting	0.00, 0.01... 20.0, 20.1... 100.0, 101....1000, 1010 ... 10000 , 10100 ... 14400 s

2.14.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% xI_n$
	Reset level	95 % I_{op} , $\pm 5\%$ or $\pm 0.1\% xI_n$
	Repeatability	$\pm 1\%$
	Transient overreach ($X/R \leq 100$)	$\leq -5\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

2.14.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	0 to 2 xI_s , 40 ms, $\pm 10\text{ms}$
		0 to 5 xI_s , 30 ms, $\pm 10\text{ms}$
t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Overshoot time	$< 40\text{ ms}$
	Disengaging time	$< 50\text{ ms}$

2.15 67/67G/67SEF Directional Overcurrent & Earth Fault

2.15.1 Reference

	Parameter	Value
θ_s	Angle setting	-95...+95 °
I	Applied current	I_n
V	Applied voltage	110 V phase-phase (63.5 V phase-earth)
V_s	Setting (V0)	0.33, 0.5, 1.0 ... 67V

2.15.2 Operate Angle

	Attribute	Value	
CA	Characteristic angle (I with respect to V)	$\theta_s, \pm 5^\circ$	
	Operating angle	forward	$CA - 85^\circ \pm 5^\circ$ to $CA + 85^\circ \pm 5^\circ$
		reverse	$(CA - 180^\circ) - 85^\circ \pm 5^\circ$ to $(CA - 180^\circ) + 85^\circ \pm 5^\circ$
	Operating angle for SEF elements with Compensated Networks Enabled	forward	$CA - 87.5^\circ \pm 2.5^\circ$ to $CA + 87.5^\circ \pm 2.5^\circ$
		reverse	$(CA - 180^\circ) - 87.5^\circ \pm 2.5^\circ$ to $(CA - 180^\circ) + 87.5^\circ \pm 2.5^\circ$
	Variation in characteristic angle	10°C to +55°C	$\pm 5^\circ$
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz	$\pm 5^\circ$

2.15.3 Operate Threshold

	Attribute	Value	
	Minimum levels for operation	I (p/f)	$> 5\% I_n$
		I (e/f)	$> 0.5\% I_n$
		V (p/f)	> 1 V
		V (e/f)	> 1 V

2.15.4 Minimum Polarising Voltage Level

	Parameter	Value
V_s	Setting (V0)	100 % V_s , $\pm 2\%$ or ± 0.5 V

2.15.5 Operate and Reset Time

	Attribute	Value
	Operate time	typically 32 < 40 ms at characteristic angle
	Reset time	typically < 65 ms at characteristic angle

2.16 81Under/Over Frequency

2.16.1 Reference

	Parameter	Value
F_s	Setting	40, 40.01... 69.99 Hz
$Hyst$	Hysteresis setting	0, 0.1... 80%
t_d	Delay setting	0.00, 0.01... 20.0, 20.5... 100.0, 101...1000, 1010 ... 10000 , 10100 ... 14400 s

2.16.2 Operate and Reset Level

	Attribute	Value
F_{op}	Operate level	100 % F_s , $\pm 10\text{mHz}$
	Reset level	overfrequency (100 % - $hyst$) $\times F_{op}$, $\pm 10\text{mHz}$
		underfrequency (100 % + $hyst$) $\times F_{op}$, $\pm 10\text{mHz}$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C $\leq 5\%$

2.16.3 Operate and Reset Time

	Attribute	Value	
t_{basic}	Element basic operate time (for ROCOF between 0.1 and 5.0 Hz/sec)	overfrequency	Typically < 110ms Maximum < 150ms
		underfrequency	Typically < 110ms Maximum < 150ms
	t_{op}	Operate time following delay	$t_{basic} + t_d$, $\pm 1\%$ or $\pm 10\text{ms}$
		Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$
	Disengaging time	< 100 ms	

Section 3: Supervision Functions

3.1 46BC Broken Conductor

3.1.1 Reference

	Parameter	Value
	NPS to PPS ratio	20...100%
t_f	Delay setting	0.02...1000 s

3.1.2 Operate and Reset Level

	Attribute	Value	
I_{curr}	Operate level	100 % $I_{set} \pm 5\%$	
	Reset level	90 % $I_{curr}, \pm 5\%$	
	Repeatability	$\pm 1\%$	
	Variation	-10 °C to +55 °C	$\leq 5\%$
		$f_{nom} - 3\text{ Hz to } f_{nom} + 2\text{ Hz}$ harmonics to f_{cutoff}	$\leq 5\%$

3.1.3 Operate and Reset Time

	Attribute	Value	
t_{basic}	Basic operate time	1x In to 0 A	
	Operate time	40 ms	
	Operate time	$t_f + t_{basic}, \pm 1\%$ or $\pm 20\text{ms}$	
	Repeatability	$\pm 1\%$ or $\pm 20\text{ms}$	
	Variation	$f_{nom} - 3\text{ Hz to } f_{nom} + 2\text{ Hz}$ harmonics to f_{cutoff}	$\leq 5\%$

3.2 50BF Circuit Breaker Fail

3.2.1 Reference

	Parameter	Value
I_s	Setting	0.005, 0.010... 2.0 x I_n
t_{CBF1}	Stage 1 Delay setting	0, 2, 0.205... 60000ms
t_{CBF2}	Stage 2 Delay setting	0, 2, 0.205... 60000ms

3.2.2 Operate and Reset Level

	Attribute	Value
I_{op}	Operate level	100 % I_s , $\pm 5\%$ or $\pm 1\% I_n$
I_{reset}	Reset level	<100 % I_{op} , $\pm 5\%$ or $\pm 1\% I_n$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

3.2.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	< 20ms
t_{op}	Stage 1	t_{CBF1} , $\pm 1\%$ or $\pm 20\text{ms}$
	Stage 2	t_{CBF2} , $\pm 1\%$ or $\pm 20\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 20\text{ms}$
	Overshoot	< 2 x 20ms
	Disengaging time	< 20ms

3.3 60CTS Current Transformer Supervision

3.3.1 Reference

	Parameter	Value
I_{thresh}	Current Threshold	0.05, 0.1... 1 xIn
V_{thresh}	Voltage Threshold	7, 8... 110V
t_d	Delay setting	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

3.3.2 Current & Voltage Threshold

	Attribute	Value
I_{op}	CT failed current level	100 % I_{thresh} , $\pm 5\%$ or $\pm 1\%$ In
	Reset level	90 % I_{op} , $\pm 5\%$ or $\pm 1\%$ In
V_{op}	CT failed voltage level	100 % V_{thresh} , $\pm 2\%$ or $\pm 0.5V$
	Reset level	110 % V_{op} , $\pm 2\%$ or $\pm 0.5V$
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		harmonics to f_{cutoff}
		$\leq 5\%$
		$\leq 5\%$

3.3.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time	30 ms \pm 20ms
	Operate time	t_{basic} , $\pm 1\%$ or $\pm 20\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 20\text{ms}$

3.4 60VTS Voltage Transformer Supervision

3.4.1 Reference (60VTS)

	Parameter	Value
V_{nps}	Vnps Level	7, 8 ... 110V
I_{nps}	Inps Level	0.05, 0.1 ... 1 x In
I_{pps}	Ipps Load Level	0.05, 0.1 ... 1 x In
IF_{pps}	Ipps Fault Level	0.05, 0.1 ... 20 x In
V_{pps}	Vpps Level	1, 2 ... 110V
t_d	60VTS Delay	0.00, 0.01...20.00, 20.50... 100, 101... 1000, 1010... 10000, 10100... 14400 s

3.4.2 Operate and Reset Level

	Attribute	Value
V_{NPSop}	Voltage NPS operate level	100 % V_{nps} , $\pm 5\%$ V_n
	Voltage NPS reset level	90 % V_{NPSop} , $\pm 5\%$ V_n
V_{PPSop}	Voltage PPS operate level	100 % V_{pps} , $\pm 5\%$ V_n
	Voltage PPS reset level	110 % V_{PPSop} , $\pm 5\%$ V_n
I_{NPSblk}	Current NPS operate level	100 % I_{nps} , $\pm 5\%$ xIn
	Current NPS reset level	90 % I_{NPSblk} , $\pm 5\%$ xIn
I_{PPSblk}	Current PPS operate level	100 % IF_{pps} , $\pm 5\%$ xIn
	Current PPS reset level	90 % I_{PPSblk} , $\pm 5\%$ xIn
$I_{PPSload}$	Current PPS operate level	100 % I_{pps} , $\pm 5\%$ xIn
	Current PPS reset level	90 % $I_{PPSload}$, $\pm 5\%$ xIn
	Repeatability	$\pm 1\%$
	Variation	-10 °C to +55 °C
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$
		$\leq 5\%$
		$\leq 5\%$

3.4.3 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time	0V to 2 x Vs
		32 ms \pm 10ms
	Operate time	t_{basic} , $\pm 1\%$ or $\pm 10\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 10\text{ms}$

3.5 60VTF-Bus Voltage Transformer Supervision

3.5.1 Reference (60VTF)

	Parameter	Value
t_d	Operate time	0.1, 0.2 ... 100s

3.5.2 Operate and Reset Time

	Attribute	Value
t_{basic}	Basic operate time	30 ms \pm 20ms
	Operate time	$t_{basic} + t_d, \pm 1 \% \text{ or } \pm 10\text{ms}$
	Repeatability	$\pm 1 \% \text{ or } \pm 10\text{ms}$

3.6 74TCS Trip Circuit Supervision

3.6.1 Operate and Reset Time

	Attribute	Value
t_{basic}	Element basic operate time	30ms \pm 10ms
t_{op}	Operate time following delay	$t_{basic} + t_d, \pm 1 \% \text{ or } \pm 10\text{ms}$
	Repeatability	$\pm 1 \% \text{ or } \pm 10\text{ms}$

3.7 81HBL2 Inrush Detector

3.7.1 Reference

	Parameter	Value
<i>I</i>	Setting (Ratio of 2nd Harmonic current to Fundamental component current)	0.10, 0.11... 0.5

3.7.2 Operate and Reset Level

	Attribute	Value
<i>I_{op}</i>	Operate level	100 % <i>I</i> , ± 4 % or ± 1% <i>I_n</i>
	Reset level	100 % <i>I_{op}</i> , ± 4 % or ± 1% <i>I_n</i>
	Repeatability	± 1 %
	Variation	-10 °C to +55 °C
		<i>f_{nom}</i> - 3 Hz to <i>f_{nom}</i> + 2 Hz
		≤ 5 %
		≤ 5 %

3.7.3 Operate and Reset Time

	Attribute	Value
<i>t_{basic}</i>	Element basic operate time	Will pick-up before operation of any protection element due to magnetic inrush
	Reset Time	Will operation until drop-off of any protection element due to magnetic inrush

Section 4: Control Functions

4.1 Check Synchronising

4.1.1 Reference

	Parameter	Value
V_{nom}	Nominal Voltage	40-160V
f_n	Nominal Frequency	50/60Hz
V_{live}	Live Setting	10% - 150%
V_{dead}	Dead Setting	10% - 150%
V_{sl}	Line Voltage Setting	10% - 150%
V_{sb}	Bus Voltage Setting	10% - 150%
V_{diff}	Voltage Differential Setting	5% - 95%
Θ_{cs}	CS Angle	1 – 90 °
Θ_{ss}	SS Angle	1 – 90 °
f_{coz}	COZ Slip	30 mHz – 250 mHz
f_{cs}	CS Slip Freq	20 mHz – 250 mHz
f_{ss}	SS Slip Freq	10 mHz – 250 mHz
t_{cs}	CS Timer	0-100s
t_{ss}	SS Timer	0-1s
f_{sps}	Split Slip	20 mHz – 250 mHz
t_{dlc}/t_{dbc}	DLC/DBC Delays	0-60s
t_{cw}	Sync Close Window	1 s – 1200s

4.1.2 Live/Dead Line/Bus Detector Elements

	Attribute	Value	
$V_{live,act}$	Live operate level	100 % V_{live} , ± 1 % V_n	
	Live reset level	$V_{dead,act}$, ± 1 % V_n	
$V_{dead,act}$	Dead operate level	100 % V_{dead} , ± 1 % V_n	
	Dead reset level	$V_{live,act}$, ± 1 % V_n	
	Repeatability	± 1 %	
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz	≤ 1 %

4.1.3 Line and Bus Undervoltage Elements

	Attribute	Value	
V_{line}	Operate level	100 % V_{sl} , ± 1 % V_n	
	Reset level	$\leq V_{line} + 4$ %	
V_{bus}	Operate level	100 % V_{sb} , ± 1 % V_n	
	Reset level	$\leq V_{bus} + 4$ %	
	Repeatability	± 1 %	
	Variation	-10 °C to +55 °C	≤ 5 %
		$f_{nom} - 3$ Hz to $f_{nom} + 2$ Hz	≤ 1 %

4.1.4 Voltage Difference

	Attribute	Value
V_{op}	Operate level	100 % V_{diff} , ± 1 % V_n
	Reset level	$\geq V_{op} - 4\%$
	Repeatability	± 2 %

4.1.5 General Autoreclose Timers

	Attribute	Value
t_{basic}	Element basic operate time	20ms ± 20 ms
t_{op}	$t_{dic}/t_{ab}/t_{cw}$	$t_{op} + t_{basic} \pm 1\%$
	Repeatability	± 20 ms

4.1.6 CS/SS/COZ Line and Bus Phase Angle Difference

	Attribute	Value
θ_{op}	Operate angle	θ_{diff} , $\pm 1^\circ$
	Reset angle	θ_{op} , $\pm 1^\circ$
	Repeatability	$\pm 1^\circ$

4.1.7 CS/SS/COZ Slip Frequency

	Attribute	Value
f_{op}	Operate frequency	f_{slip} , ± 10 mHz
	Reset frequency	f_{op} , - 10 mHz
	Repeatability	± 10 mHz

4.1.8 CS/SS Timer

	Attribute	Value
t_{op}	Operate time	$\pm 1^\circ$, +20ms

Note: minimum synchronising time following restoration of voltage from a dead condition is 320ms.

4.1.9 Split Angle Detector

	Attribute	Value
θ_{op}	Operate angle	θ_{split} , $\pm 1^\circ$

4.1.10 Split Slip Frequency Detector

	Attribute	Value
f_{op}	Operate frequency	f_{slip} , ± 10 mHz
	Reset frequency	f_{op} , - 10 mHz
	Repeatability	± 10 mHz

4.2 Loss of Voltage (LOV) Loop Automation Function

4.2.1 Reference (LOV-A/X Dead/Live)

	Parameter	Value
Live Vs	Setting	5, 5.5... 80V
Dead Vs	Setting	5, 5.5... 80V

4.2.2 Operate and Reset Level

	Attribute	Value	
V_{op}	Operate level	100 % LiveVs, $\pm 2\%$ or $\pm 0.5\text{ V}$	
	Reset level	100 % DeadVs, $\pm 2\%$ or $\pm 0.5\text{ V}$	
	Repeatability	$\pm 1\%$	
	Variation	-10 °C to +55 °C	$\leq 5\%$
		$f_{nom} - 3\text{ Hz}$ to $f_{nom} + 2\text{ Hz}$	$\leq 5\%$

4.2.3 Reference LOV Automation Timers

	Attribute	Value
t_{op}	LOV Primed Time	0, 1 ... 600s
t_{op}	LOV Action Delay	0, 1 ... 600s
t_{op}	LOV-A Action Delay	0, 1 ... 600s
t_{op}	LOV-X Action Delay	0, 1 ... 600s
t_{op}	LOV Sequence Time	0, 1 ... 600s
t_{op}	LOV Reclose Delay	0, 1 ... 600s
t_{op}	LOV SOTF Time	0, 1 ... 600s
t_{op}	LOV Reclaim Time	0, 1 ... 600s
t_{op}	LOV Memory Time	0, 1 ... 600s

4.2.4 Operate Time LOV Automation Timers

	Attribute	Value
t_{op}	Accuracy	t_{op} , $\pm 1\%$ or $\pm 50\text{ms}$
	Repeatability	$\pm 1\%$ or $\pm 50\text{ms}$